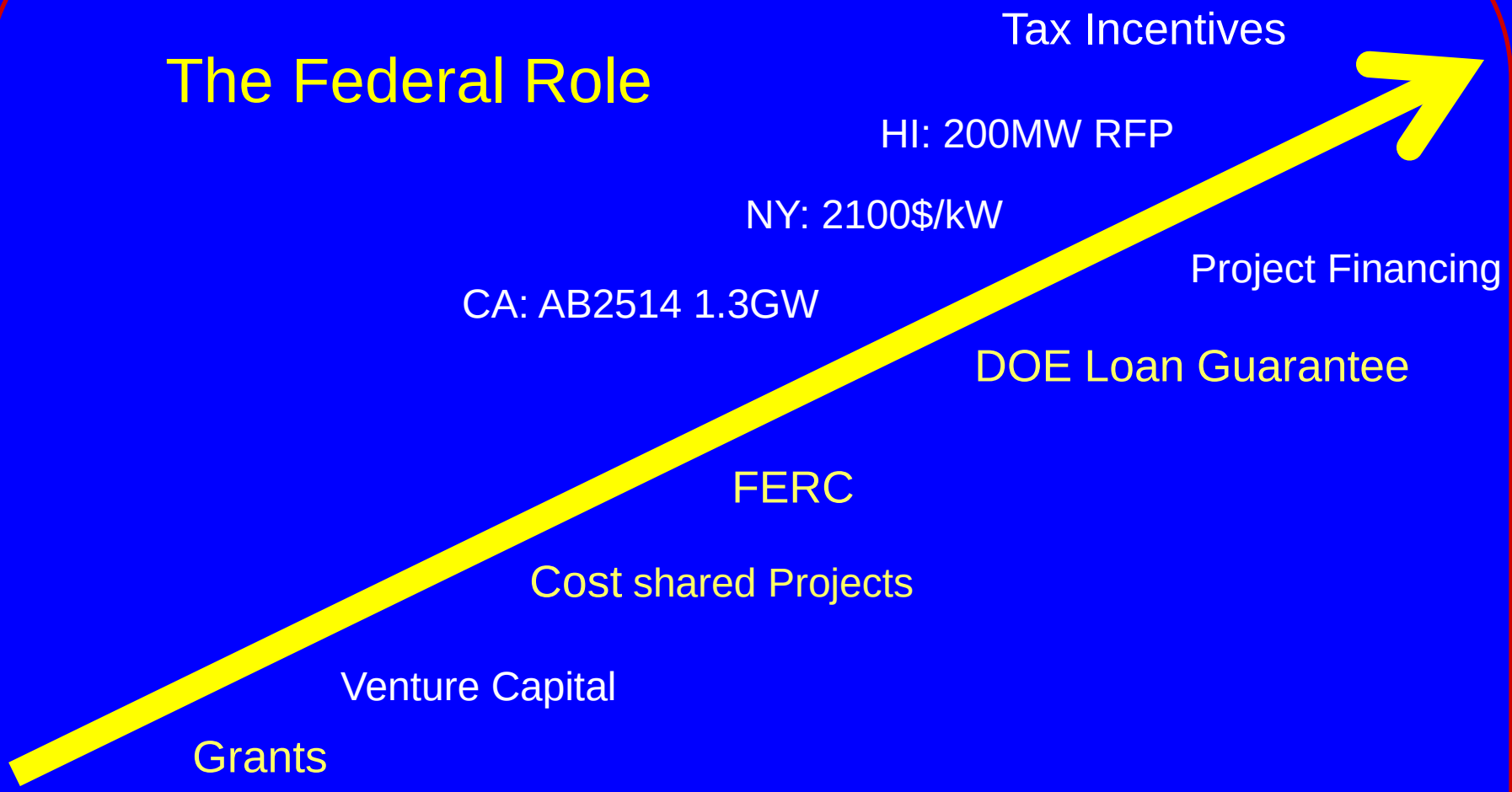
Progress in U.S. Grid Energy Storage Systems

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE
Presented by Dan Borneo, Sandia National Laboratories

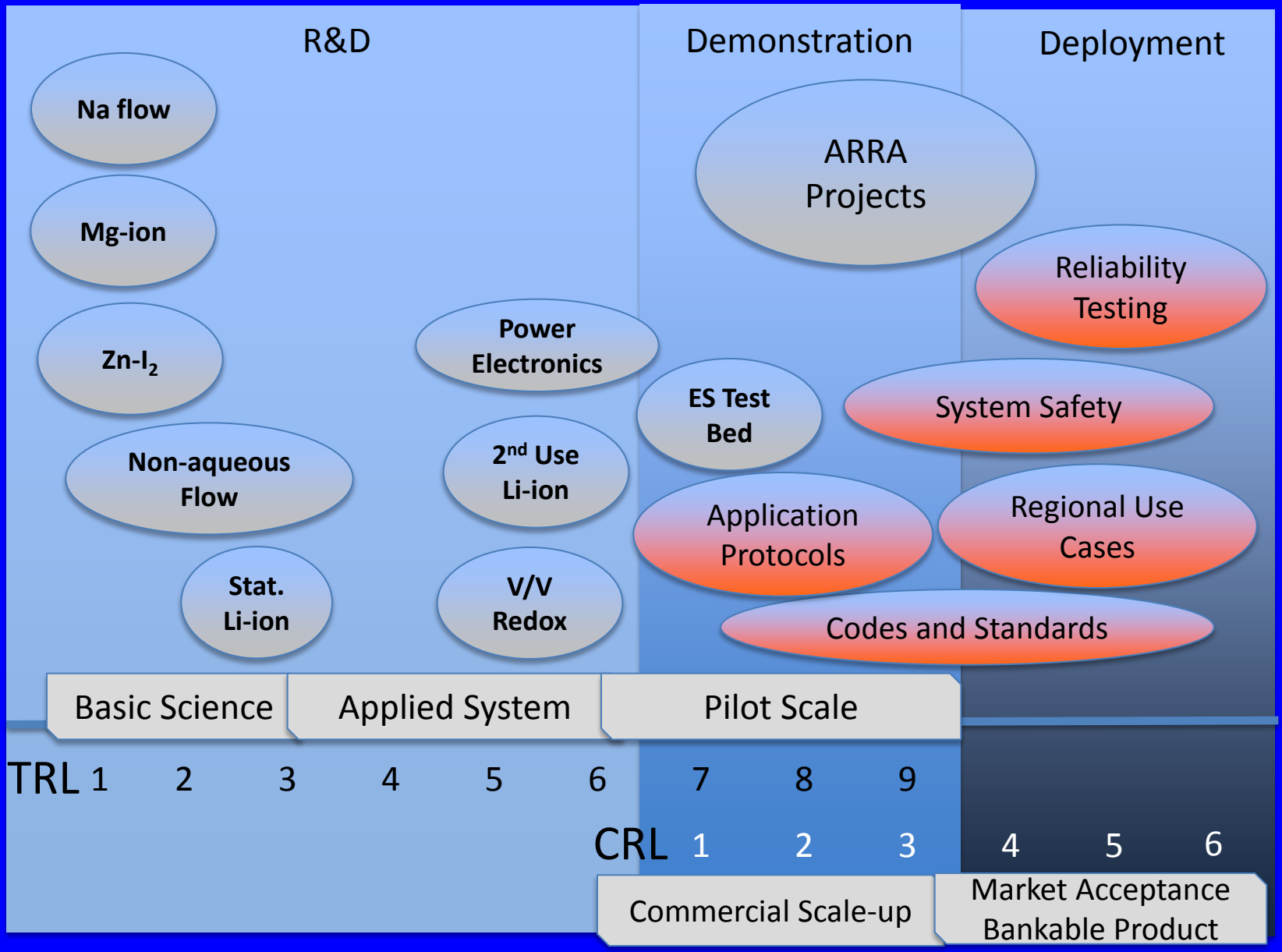
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

The Federal Role



Research Development Demonstration Niche Market Mass Market

DOE-OE Project Mapping



Technology Development Activities

Stakeholder Acceptance Efforts

ARRA Stimulus Funding for Storage Demonstration Projects

Leveraged Funding: $185M vs. $585M

- Show technical feasibility
- Gather cost data
- Stimulate regulatory changes
- Generate follow-on projects

Frequency Regulation

DOE Loan Guarantee – Beacon:
20MW Flywheel Storage for
Frequency Regulation in NY-ISO
Commissioned July 2011
210,000 MWh of FrequReg delivered!

- This project provided the basis for FERC to establish "PAY FOR PERFORMANCE"!

ARRA Project – Beacon
Hazleton, PA.
20MW Frequency Regulation for PJM.
Start: June 2013 - 16 MW installed
Drawing Revenue: 17,000 MWh
Commissioning of full 20MW Aug. 2014

Frequency Regulation using
Energy Storage is now
a Commercially viable Business
in FERC compliant Regions!

ARRA – Duke Energy / Younicos (Xtreme)

36MW / 40 min battery plant – Remote Operation
Ramp control, Smoothing, Frequency Regulation
Linked to 153MW Wind farm at No-Trees, TX

Ribbon Cutting
March 28, 2013
23,000 MWh delivered

- This project was crucial as a pilot for ERCOT's consideration to establish "PAY FOR PERFORMANCE"!

Clean Tech 100 in 2010 / 11

ESNA Best Project 2013

Flow Batteries

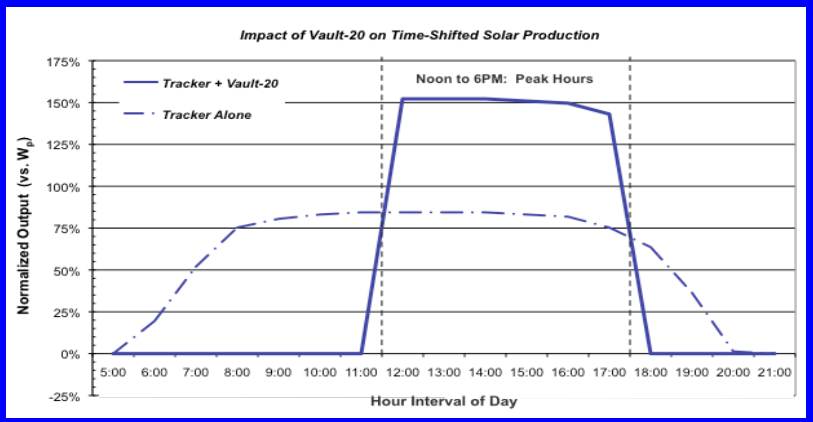
ARRA - Enervault:

250kW/4hr Fe-Cr Flow Battery

PV: 300 kW
Storage: 250 KW
Peak output: 450kW
Storage Cost: +16%
Storage Value: +84%
Commissioned May 22, 2014

Tracking PV in Almond Grove

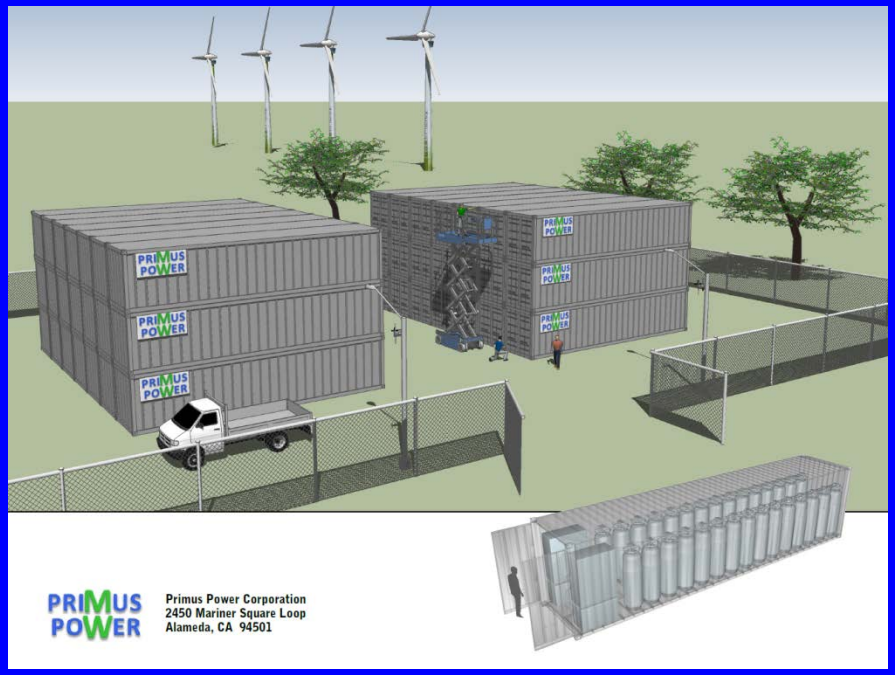
Installation of Tanks at Turlock



Leveraging PV with Storage

ARRA- Primus Power:

25MW / 3hr battery plant for the Modesto, CA Irrigation District,
Providing equivalent flex capacity of a 50MW - $73M gas turbine



	Gas Turb	Storage
Cap Cost:	$73M	$50M
Ramp:	300 sec	5 sec
CO_2	66k met. tons	0
Area:	1 acre	¼ acre

2012- 50 Hottest Tech Startups
2011-GoingGreen Global 200

PRIMUS POWER

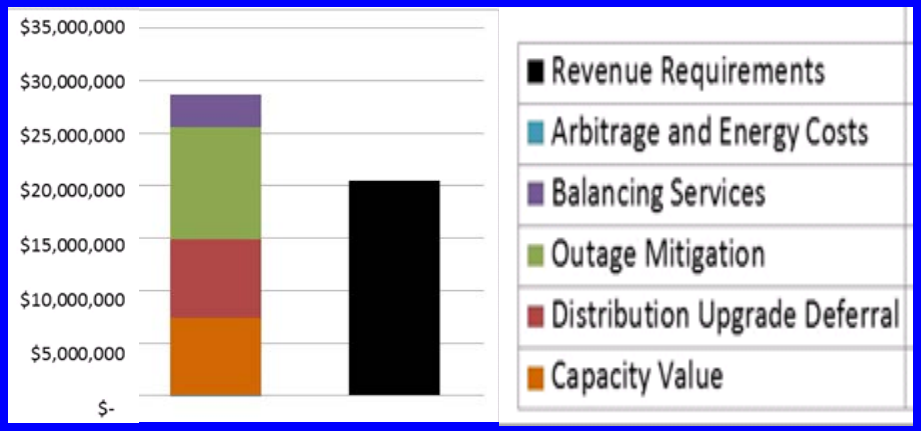
BOSCH

EnergyPod 250kW / 1MWh Power Box

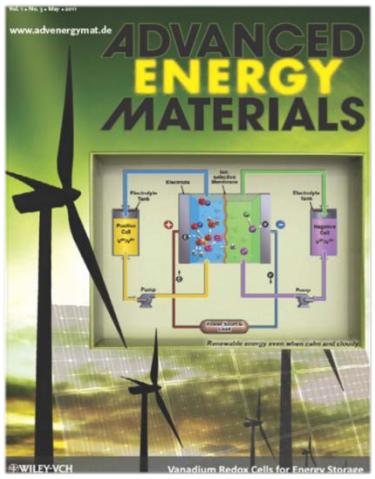
BPA / Puget Sound Grid Project:

PNNL Analysis Program selects cost-effective site and scale to optimize Value Stream

Primus Power, developed under ARRA funding to install 500kW / 2hr ZnBr Flow Battery



Materials Research at PNNL:



Liyu Li *et al.*, Stable Vanadium Redox Flow Battery with High Energy; 1, 394-400, 2011

PNNL, Nov. 2011

Mixed Acid Electrolyte for V/V Flow Batteries yields 2x energy density

Licensed to:
- Imergy
- Joule-Watt
- UniEnergy (UET)

V/Fe Flow Battery technology

Licensed to: Aartha USA (WA)
10x Scale-up Development at PNNL

2012 Federal Laboratory Consortium Award for Technology Transfer

Advanced Batteries

ARRA - Southern California Edison / LG Chem – Li-Ion:

8 MW / 4 hr battery plant for wind integration at Tehachapi, CA.

Tehachapi: 4,500MW Wind by 2015!

Construction of Facility and Commissioned: Sept. 2014
Integrator: ABB

8MW / 32MWh Storage Plant

2 ARRA Projects using EastPenn Ultra-Batteries

Public Service NM:

500kW, 2.5MWh for smoothing of 500kW PV installation;
Commissioned Sep. 2011

EastPenn, PA

3MW Frequency Reg.
1MW 1-4hrs Load Management during Peak Periods

Commissioned June 2012
Over 700,000 kWh of regulation Services delivered to PJM !

Integrator: Ecoult

Hydro Tasmania,
Australia's largest battery
on King Island
Installed: December 2013

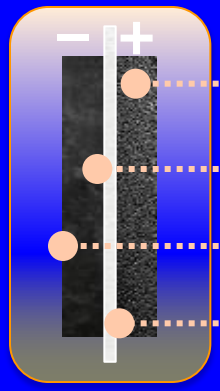
3MW / 1.6MWh
EastPenn Ultrabattery
for renewable integration
and a totally green Island**!**

2013 Australia National
Innovation Award

Integrator: Ecoult

Reduces Diesel >65%

ARRA – Aquion Energy: Aqueous Hybrid Ion (AHI) Battery



Cathode: Manganese Oxide

Anode: Carbon composite

Electrolyte: Aqueous solution

Separator: Cellulosic material

- DOE ARRA $5 M – VC $100 M
- Over 120 employees!

ARRA – SEEO: Solid Polymer Electrolyte Battery

SunShot PV Installation with 10kWh Battery

Compressed Air

ARRA - SustainX:

Development of a Totally Green Isothermal Compressed Air Energy Storage System

- MOU for Full Scale Deployment with Funding from DOE, POSCO and Korean Ministry of Trade in preparation

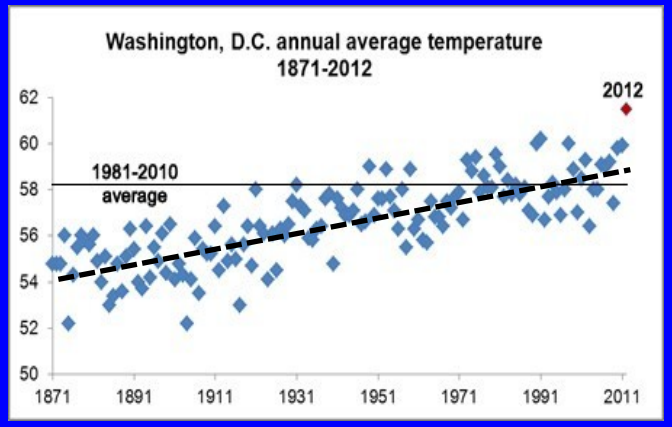
1.65MW Prototype Commissioned Dec. 2013

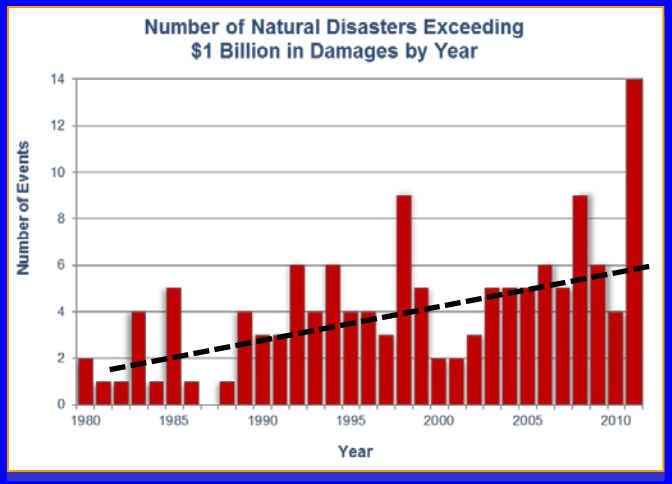
GE Ecomagination Award
2010/11/12 Global Cleantech

RESILIENCY

Energy Storage for Emergency Preparedness

Every $1 on protection measurements
Can prevent $4 in repairs after a storm!





Trends indicate the situation will get worse not better!!

Some 50% of Diesel Generators failed to start during the Sandy Emergency

Storage allows Microgrids to provide essential Services over an extended Time Period

During non-emergency Periods Storage can provide Demand Management for the User and compensated Services to the Grid

Apartment Buildings – Campuses – Schools – Shopping Centers – Community Centers – Nursing Homes – Hospitals – Police Stations – Gas Stations – etc. etc

Vermont Public Service Dept. – DOE
Green Mountain Power

Solicitation issued by VPS. Joint funding by VPS, DOE-OE, GMP

Rutland, VT
4MW / 3.4MWh of storage
Integrated with 2MW PV
Integrator: Dynapower

Groundbreaking: Aug. 12, 2014

Situated on Brown Field Area

Ancillary grid services, peak shaving during high load periods

System can be islanded to provide emergency power for a resilient microgrid serving a highschool/emergency center.

Washington State Clean Energy Fund:

Solicitation for $15M for Utility Energy Storage Projects

Selected Projects with UET V/V technology:

- Snohomish PUD (2MW / 6.4MWh) – PNNL -- U of WA
- Avista (1MW / 3.2MWh) – PNNL -- 1 Energy -- WA State

PNNL will participate in both Projects, providing siting analysis, benefit optimization and system testing

INDUSTRY TOOLS

SNL Energy Storage System Analysis Laboratory

Reliable, independent, third party testing and verification of advanced energy technologies from cell to MW scale systems

GS Battery at DETL

Energy Storage Test Pad (ESTP)

Milspray Deka Battery under testing

System Testing

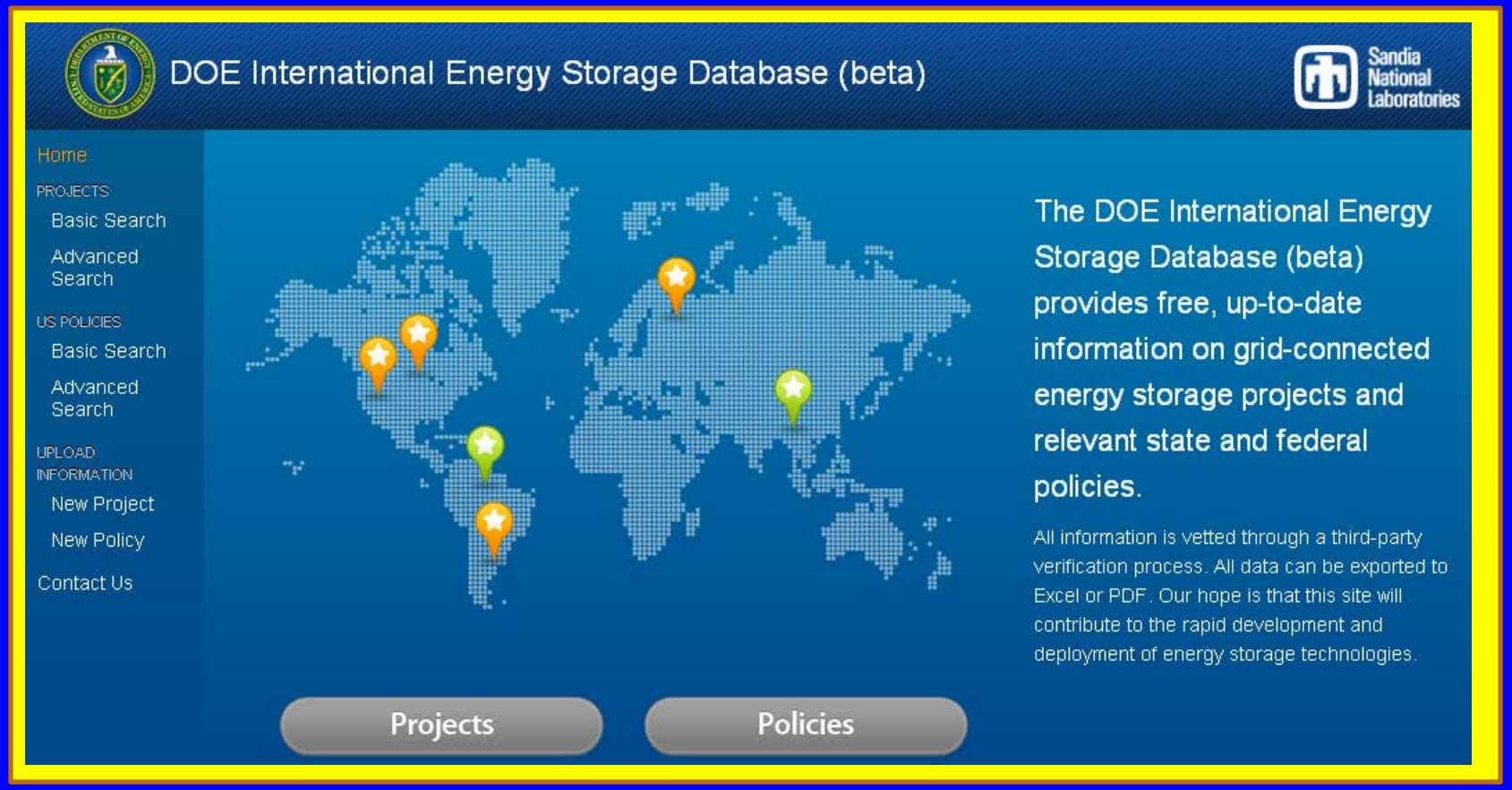
- Scalable from 5 KW to 1 MW, 480 VAC, 3 phase, Both power and energy use tests.
- 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
- Subcycle metering in feeder breakers for system identification and transient analysis
- Safety Analysis

DOE International Energy Storage Data Base

energystorageexchange.org supported by Strategen

Over 1000 energy storage projects from 58 countries.

50 energy storage technologies are represented



Energy Storage Technology Advancement Partnership
ESTAP

ESTAP has produced 21 webinars, in the areas of energy storage policy, and energy storage project case studies.
Some examples: http://www.cesa.org/webinars/

Policy:

California's New Energy Storage Mandate (11/19/13)
Introduction to the Energy Storage Report for State Utility Regulators (4/24/2013)
State Electricity Storage Policies (7/12/2012)
Energy Storage and Renewable Portfolio Standards (12/19/2011)

Technology/Projects:

Optimizing the Benefits of a PV and Battery Storage System (9/16/13)
Duke Energy's Storage Projects (11/13/13)
Maui EnergyStorage Case Study (3/6/13)
Applications for Redox Flow Batteries (12/20/12)

Grid Energy Storage Safety Initiative

DOE identified *Validated Safety* as a critical need for the success of grid energy storage.

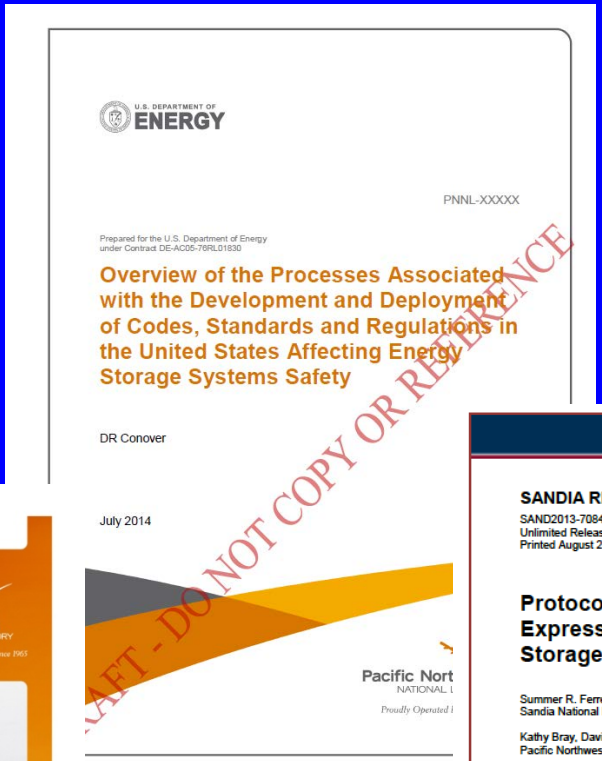
The ability to validate the safety of energy storage systems will:

- Decrease human and financial risk,
- Minimize installations costs,
- Accelerate acceptance of new storage technologies.

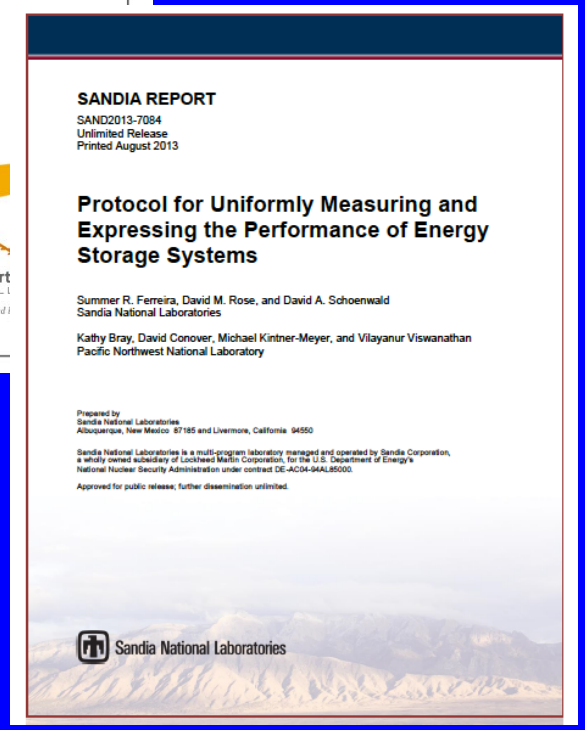
To address this need DOE is engaging key energy storage stakeholders:

- DOE OE Energy Storage Safety Workshop, February 2014
- DOE OE Webinar on Energy Storage Safety, April 2014
- DOE OE Safety Panel – ESA annual meeting and conference, June 2014
- DOE OE *Strategic Plan on Energy Storage Safety* – September 2014

Safety Web site: Documents



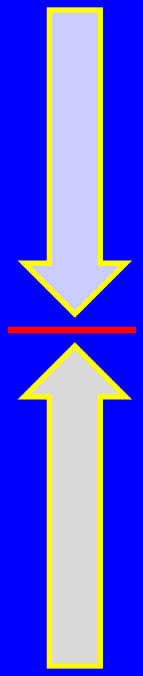
Storage Safety 101



Storage Performance Protocol

Directory of Applicable Codes

Storage Economics:



The Cost of a Storage System depends on the Storage Device, the Power Electronics, and the Balance of Plant

The Value of a Storage System depends on Multiple Benefit Streams, both monetized and unmonetized

Power Electronics 20-25%

Energy Storage Device 25-40%

Facility 20-25%

LCOE depends on Application! Policy is important!

Energy Storage is Coming of Age!

New Cost effective Technologies

New Benefit streams opened

Major solicitations / Mandates in:
California (1.3 GW)
Hawaii (60-200 MW)
Ontario (50 MW)
Involvement of States: VT, WA, OR

DOE Loan Guarantees Solicitation